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## OF
# THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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## THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

VOL. XXV, No. 6 JULY-AUGUST WHOLE No. 205

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PLATE XIV

PHOTOGRAPH TAKEN AT A MEETING OF THE TORONTO ASTRONOMICAL SOCIETY
(Probably 1888)

*From left to right*: G. G. Pursey, A. Elvins, S. Roberts, D. J. Howell, A. F. Hunter, A. F. Miller.

PLATE XV

EARLY PHOTOGRAPHS OF THE ROYAL ASTRONOMICAL SOCIETY OF CANADA (by D. J. Howell)

*Above*: On the lawn of Mr. D. J. Howell, Lambton Mills, Ont. (About 1900). *Left to right*: Z. M. Collins (with hat on), Visitor, A. Horton, A. Elvins (in front), W. B. Musson, Visitor, Miss M. A. Howell, Mrs. Musson, Mrs. Webber, J. Webber, Miss McEachren (in white), J. E. Maybee, I. A. Paterson, D. J. Howell (side view), Miss Eva C. Howell, G. G. Pursey (blurred).

*Below*: At Mr. Howell's house, 218 Bleecker St., Toronto. (About 1888). *Left to right*: Mr. Barters, A. Elvins, A. F. Miller, G. G. Pursey, W. I. Moore.

*Journal of the Royal Astronomical Society of Canada*, 1931.

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## RECOLLECTIONS OF THE EARLY DAYS OF THE ASTRONOMICAL SOCIETY


BY DAVID J. HOWELL


*(With Plates XIV, XV)*

DURING my connection with the society, it has been known under the names of the Toronto Astronomical Society; the Astronomical and Physical Society, still again, the Toronto Astronomical Society, and its present name, the Royal Astronomical Society of Canada. (*See* Note 1, at end). My first appearance in the group of men composing the society was at a small and informal gathering at Mr. Andrew Elvins' house at 11 St. Vincent St. Here I had my first view of the moon through something larger than an opera glass. Mr. Elvins had the 3-inch telescope that he had constructed, mounted on a tripod, on his little lawn. Later in the evening I had my first view of Jupiter and his moons. This telescope was given to me after Mr. Elvins' death and is a treasured possession, as is also his small field glass. (See Note 2.)

Of the group present on that first evening I can remember Mr. G. G. Pursey and Mr. G. H. Armstrong. The little house at 11 St. Vincent St. has disappeared; brick houses replacing it. The house No. 15 is still standing, with the old and the new number on it. The street itself has been merged into the present Bay St., and the widening of it cut off practically all of the little lawn where Mr. Elvins set up his telescope.

I can remember Mr. Elvins' enthusiasm over Mr. A. F. Miller's 4-inch Wray refractor with its equatorial mounting. This was before I had met Mr. Miller, being introduced to him later by

Mr. Elvins in his shop in the Yonge St. Arcade. This shop, in the early days of the society, was quite a meeting place for those interested in astronomy. Here I met Mr. D. K. Winder, Mr. T. S. H. Shearmen, and I think Mr. J. H. Kedzie.

At a later meeting in Mr. Elvins' house there were nine or ten present. The gathering was a little more formal; a paper was read, and there was considerable discussion. Here I met Mr. A. F. Hunter. I think that Mr. Miller was present. Others that I remember at this meeting were Mr. Pursey, Mr. Armstrong, Mr. S. E. Roberts, Mr. C. Gordon Richardson, F.C.S., and Mr. M. Turnbull.

I have recollection of two meetings at the house of Mr. Samuel E. Roberts, 1 Avenue Street, a short street that ran from the head of Elizabeth St., which did not cross College Avenue at that time, to University Ave. It was separated from College Avenue by a fence. On the site of these houses and Avenue Street the present General Hospital is situated. It was at the second meeting in Mr. Roberts' house that the flash light picture was made: (Plate XIV) this was one of my early flash light pictures and was made in or with the first camera that I possessed. I think this was in 1888.

A number of meetings were held at our house when my family lived at 218 Bleecker St., in 1887-89. It was here that the flash light picture that is shown in Plate XV was made. In this group is Mr. Miller, Mr. Pursey, Mr. Elvins, Mr. Barters, a friend who came occasionally but whose name does not appear on the list of members, and Mr. W. J. Moore. Mr. Moore was, for many years, a workman with Mr. James Foster, the instrument maker. The object shown on the table is a Wimshurst influence machine, made by Mr. Moore. With this machine and Leyden jars we were able to get a spark about 13 inches long, and which was photographed. Mr. Moore has been in business for himself for a number of years, and is still quite busy at 160 Spruce St., where he has his shop.

At a subsequent meeting at our house, Mr. Miller brought and introduced Mr. George E. Lumsden. The paper of the evening was on "Photography and its Application to Astronomy," read by the writer. In addition to the paper a demonstration of photography was given. A flash light picture of Mr. Elvins was made and developed, then a lantern slide made from the negative and thrown on the screen; all within an hour. Mr. Lumsden was

greatly interested in it all, and was proposed for membership. This was in 1889. In the following year the society was incorporated as the Astronomical and Physical Society of Toronto. (See Note 3).

Some years later, when Mr. Lumsden was president, there were a number of out-door meetings. This was the time when Mr. J. R. Collins, Mr. W. B. Musson and Mr. J. E. Maybee were all very active in the affairs of the society. One of these out-door meetings was held at the writer's house in Lambton Mills, in 1900 or 1901, the members coming in the afternoon, and being entertained on the lawn with refreshments. The telescopes that had been brought with them, (shown in the illustration, Plate XV) were used in the evening. In the picture of this gathering may be noticed, Messrs. J. R. and Z. M. Collins, Mr. Albert Horton of Ottawa, elected an associate in that year; Mr. Elvins, Mr. Musson, a neighbour, Miss Howell, Mrs. Musson, Mr. and Mrs. John Webber (visitors)—Mr. Webber is still living, getting well on to the century mark; Miss McEachren, for many years a constant attendant; Mr. Maybee, Mr. John A. Paterson, Mr. Howell, Miss Eva Howell, and a blurred image of Mr. Pursey. This was one of the pleasant out-door meetings held by the society, but of which there are no records in the transactions.

*Note 1.*—The first name of the society was the Toronto Astronomical Club. It was shortly changed to that of the Toronto Astronomical Society. The organization and its meetings had been discontinued for some years when my interest was enlisted by Mr. Elvins. At one time or another I have met all of the original members except Mr. Ridgeway and Mr. Brunt.

*Note 2.*—This little telescope, 1½ inch four-draw field glass made by Chadburn and Sons, Opticians, etc., to H.R.H. the late Prince Consort, Liverpool, is a good little glass. We had this mounted or clasped to a swivel that could be screwed into a post or window frame or even attached to a camera tripod. It could be made quite rigid. It was this little glass that I used through a screen in my window for projecting the image of the sun for the observation of spots. It was on one of these occasions that a flock of wild geese winged their way in "V" shaped formation at a great height across the disc of the sun, as described in the society's first *Annual Report* for 1890-91, page 8.

I bought this glass from Mr. Elvins a year or two before he died. I paid him $5.00 for it. He asked $1.50, which I said was a ridiculous price. He said that what I had paid him was altogether too much. However, he was quite pleased at having the extra pocket money. It is still in my possession.

*Note 3.*—It was because Mrs. Lumsden did not like the word "Physical" that the name of the society was changed back to the Toronto Astronomical

Society. She had an idea that the word was too closely associated with the functions of the body or with physic in medicine and was not a nice word. Mr. Lumsden told me this himself. With a number of the members I opposed the change because the name of the society was a good name and the reasons for the change altogether too trivial for a serious organization to consider. Mr. Lumsden was, however, determined on the change and as the other members did not want to offend him, my vote was the only one cast against it. This opposition earned for me the displeasure of both Mr. Lumsden and Mr. Miller. They criticized severely my use of the society's lantern, which had been presented to the society by Mr. Elvins, Mr. Pursey and myself who had been joint owners, and which had been loaned to the society for its use for years. It was this friction that caused me to lose interest in the work of the society at that time.

# THE STRUCTURE OF THE EARTH'S ATMOSPHERE*

By H. Grayson Smith

IT is intended in the present paper to deal mainly with that part of the earth's atmosphere which is of interest to the meteorologist, and to confine the discussion as far as possible to well-substantiated facts about the structure of the lower levels. However, as an introduction, it will be of interest to examine a general picture of the structure as a whole. This is given graphically in Fig. 1. First are shown the principal sources of information available for the study of the atmosphere up to a height of 180 km., —direct observation by instruments only up to about 22 km., and above that various natural phenomena, the most important of which is perhaps the aurora borealis. Auroral displays have several times been observed extending to a height of 500 km., and on one occasion in Norway to 750 km., showing that traces of the atmospheric gases are still found at these heights, although with a density many times less than the density of the residual gas in the best obtainable "vacuum".

The figure shows also the vertical distribution of pressure and density, and the composition of the gas mixture at the various levels. For the upper levels these are necessarily approximate. All three depend upon the assumption of a reasonable figure for the temperature, which has been taken to be about 300° A. at levels above 50 km., in agreement with Lindemann and Dobson.[1] A temperature as high as, or higher than, the average temperature at the surface of the earth appears to be required in this region in order to explain the phenomena of the ozone layer, although it is known to be very much colder in the intermediate levels.

The composition is given after Chapman and Milne,[2] and is calculated from the known composition of the lower levels. It is assumed that the proportions of the different gases are kept approximately uniform by mechanical mixing (except for the loss of water vapour) up to 20 km., above which mixing ceases and the

*Based on a lecture delivered before the Victoria Centre of the Royal Astronomical Society of Canada, October 26, 1930.

lighter gases are able to rise. According to this calculation, the extremely rare outer atmosphere above 120 km. must consist almost entirely of the lightest constituent, which is here taken to be helium. That this is correct is still somewhat doubtful, as, if there is any appreciable amount of hydrogen at any level, that gas must become the main constituent of the higher levels, and helium would not then be an important factor anywhere. Chap-

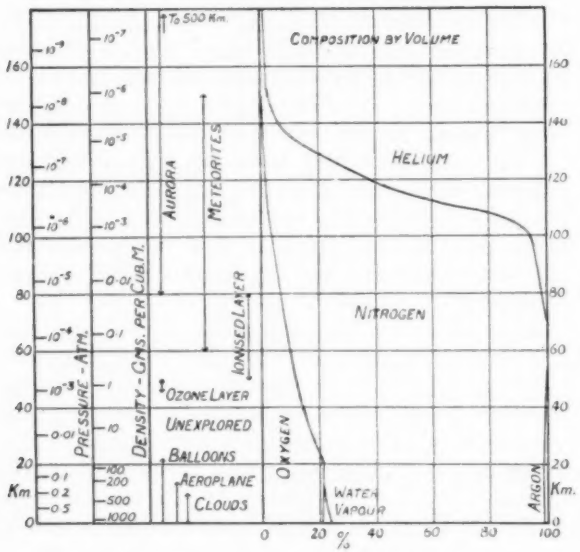



Fig. 1.—Composition, etc., of the Upper Atmosphere

man and Milne exclude hydrogen from consideration on the grounds that it is inappreciable at the surface, and that its light molecules travel with such high speeds that many of them would be able to escape from the attraction of the earth altogether, and so in time all the hydrogen would disappear. Again, if the temperature were sufficiently high, all the helium might be lost, and water vapour or nitrogen would become the important factor. Evidence from the spectrum of the aurora, the only direct evidence

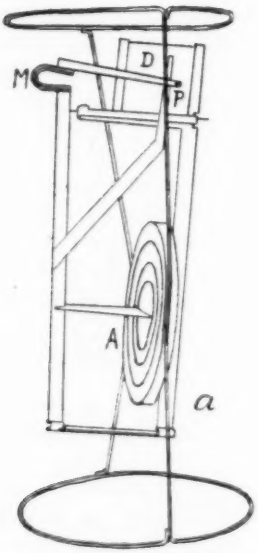
available, does not exclude the possibility of hydrogen entirely, but indicates that helium is more likely.

The upper levels of the atmosphere above about 40 km. are already at a sufficient distance from our observatories that methods essentially the same as those of astrophysics must be applied in their study. What is known experimentally has been derived mainly from spectroscopic and other studies of the light of the aurora and of meteorites, and from studies of the absorption of sunlight and starlight by the ozone, together with a certain amount of information derived from the study of the reflection of radio waves in the ionized layer. This might therefore be described as the region of electrical phenomena in distinction from the region of meteorological phenomena. It appears, however, from Fig. 1, that 9/10 of the mass of the atmosphere is below 16 km., the level where the pressure is 0.1 atmosphere, and that half of it is below 5 km. Interesting as it may be to learn as much as possible about the outer atmosphere, the meteorologist, who is mainly concerned with the processes of weather, can usually afford to neglect the tenth which is beyond the range of his instruments.

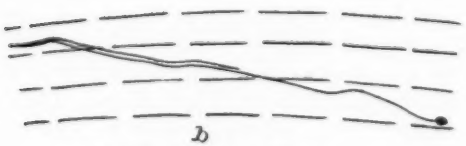
## The Exploration of the Lower Atmosphere

Nowadays it is possible actually to go up and observe directly the conditions in the atmosphere up to about 12 km., some 3 km. higher than the top of Mt. Everest, and some valuable data have been obtained by means of instruments carried on aeroplanes undertaking altitude tests. However, such flights are expensive and infrequent, and very much more information has been obtained by the use of small unmanned balloons carrying self-recording instruments, which can travel to even greater heights than have so far been possible for aeroplanes, one isolated case being on record of such a balloon reaching a height of 35 km. Some use has also been made of kites, but their range is severely limited by the great weight of the wire required to hold them. The instruments used for flights with these "sounding-balloons" vary somewhat in different countries, but the principle involved is everywhere the same. A combined instrument makes simultaneous records of the pressure and temperature during the flight, frequently including

also the humidity. Then, since the variations of temperature are known, the height of the balloon at any time can be calculated from the pressure. From this the temperature, pressure and humidity at any given height can be found at once. Separate observations of the heights of clouds, and of the wind currents in the free atmosphere, give sufficient data for a fair understanding of the structure and processes of the levels up to about 25 km.




DINES METEOROGRAPH




METEOROGRAPH TRACE

FIG. 2.—(a) THE DINES METEOROGRAPH.
(b) A SAMPLE RECORD OBTAINED.

The instrument used in British countries is the Dines meteorograph shown in Fig. 2*a*. The pressure is recorded by means of the aneroid box *A*, which is connected as shown to a fine needle-point which makes a trace on a silvered glass plate *D*. Horizontal motion of the needle then corresponds to change of pressure. At the same time a change of temperature affects the bi-metallic strip *M* and causes a vertical displacement of the needle. The trace which is obtained when the instrument is carried aloft by the balloon is represented by the irregular line in Fig. 2*b*. The broken circular arcs on the same figure are calibration lines made in the laboratory at known temperatures and pressures before the instrument is sent up. When the humidity is required a second needle is operated by a fine hair. The whole instrument is about 8 inches in height, and weighs about 4 ounces, and as the glass plate on which the record is obtained is only about 1 inch square, the trace has to be measured under a microscope. The instrument is placed in a light aluminium cylinder in order to protect it from the direct rays of the sun, and then fastened in the centre of a frame made of three wicker sticks in order to protect it from damage when it strikes the ground. It is carried by a hydrogen-filled rubber balloon about 4 feet in diameter when launched, the whole apparatus weighing a little over a pound. As the balloon rises it expands owing to the release of the external pressure, and eventually bursts, usually at a height of 12 to 20 km., at the same time being carried by the wind to horizontal distances of 100 to 500 miles. When it falls the torn fabric acts as a parachute and prevents the instrument from striking the ground with sufficient speed to cause damage. Tags attached to the instruments offering rewards for their return ensure the recovery of the majority of those launched, usually within a few days.

The unavoidable delay in the recovery of the records, increased by the considerable amount of work involved in deciphering them under the microscope, is the principal disadvantage of the method. It is impossible, for instance, to obtain any information soon enough for it to be of use in the preparation of the daily forecasts, although it would obviously be of very great assistance to the forecaster if he knew the conditions in the free atmosphere where the clouds and rain are formed. At the same time statistical data concerning

the upper air are not of the same interest to the general public as the widely published statistics of surface weather. This lack of immediate commercial value, together with the very considerable expense involved in the work, have prevented the establishment of the network of stations taking daily observations which would be necessary in order to make a truly complete study of the subject. In order, however, that such work as is done in different countries may be of the greatest possible value to the theoretical meteorologist, balloons are launched by international agreement on certain specified days from a number of stations at various points over the earth. The conditions are then known fairly completely for these particular days, even if they are not known for every day in the year. The Meteorological Service of Canada has been co-operating in this work for a number of years by maintaining two stations from which instrument-bearing balloons are launched on the agreed days. At present these two stations are Goderich, Ont., and Calgary, Alta.

## The Variation of Temperature with Height

The essential features of the structure of the lower atmosphere are evident in a study of the temperature distribution alone, with the aid of the ordinary laws of the behaviour of gases. Fig. 3 shows graphically the mean summer and winter temperatures at various heights over Europe, obtained from the averages of a large number of balloon flights at different stations.[3] From the ground up to about 11-12 km. (in summer) the diagram shows a fairly uniform temperature gradient, or decrease of temperature with height, of about 7° C. per km., usually with a slower decrease near the ground. Then above this level the temperature remains very nearly constant at about −50° to −58° C. up to the greatest height yet reached in any of the flights. It is found that the atmosphere must be divided into two distinct layers; the "troposphere", or the region of convection, where the temperature decreases with the height, and the "stratosphere", or isothermal layer, where the temperature is practically constant.

The depth of the lower layer as well as the temperature of both layers, varies from point to point over the surface of the earth.

Fig. 4 shows an imaginary cross-section of the atmosphere along a meridian from the equator to the poles, with the normal vertical distribution of temperature at various latitudes indicated by isotherms drawn through levels of the same average temperature.[4]

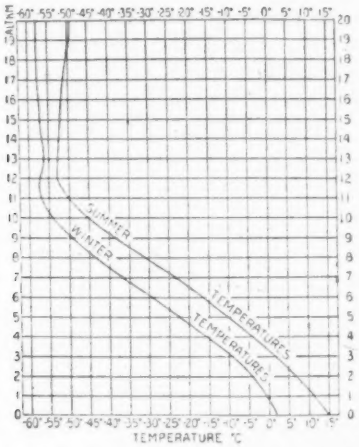



FIG. 3.—VERTICAL DISTRIBUTION OF TEMPERATURE

The left half of the diagram represents summer conditions, and the right half winter. The thick hatched line represents the position of the "tropopause", or the division between the troposphere and the stratosphere, and the vertical extensions of the isotherms above the tropopause show the distribution of temperature within the stratosphere, where there is no variation with height, but a marked variation with latitude. Over the equator the temperature continues to fall up to a very great height, while over the poles the stratosphere is quickly reached, with the immediate result that the stratosphere and the upper layers of the troposphere itself are actually coldest over the equator, and warmest over the poles. The following table gives approximately the average conditions:

| Latitude | Surface Temp. | Height of Tropopause | Temp. of Strato. |
|---|---|---|---|
| 0° | 27° C. | 18 km. | −85° C. |
| 45° | 12° C. | 11 km. | −55° C. |
| 90° | −20° C. | 5 km. | −35° C. |

It is seen that the stratosphere is everywhere exceedingly cold, so that the average temperature over the whole earth at a height of 20 km. is about −60° C., as compared with an average surface temperature of about 14° C. It was stated earlier, however, that the temperature at very great heights, say above 50 km., is believed to be as warm as, or even warmer than, the surface. This would indicate that there is a limit to the depth of the isothermal layer, although as yet no balloon flights have shown any indication of more than a slight rise of temperature, and the level where the return to higher temperatures takes place is at present unknown. As will be shown below, however, there is no difficulty in supposing that the atmosphere does warm up again somewhere between 30 and 50 km.

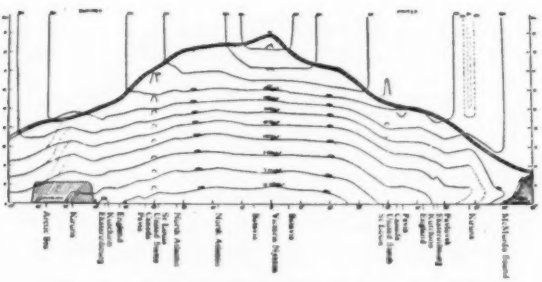


FIG. 4.—UPPER AIR TEMPERATURES OVER THE EARTH.
The shaded band with vertical hatching indicates the probable position of the tropopause. Exceptional high temperature; exceptional low temperature, probably local.

With regard to the variation with latitude in the stratosphere, a careful study has recently been made by Rao[5] of as many as possible of the highest flights all over the world. Dealing with the slight increase of temperature within the stratosphere over the equator and in middle latitudes, he has found corresponding slight decreases in high latitudes, and concludes finally that the anomaly of the cold equator disappears at about 25 km., where probably the temperature is about −50° C. all over the earth. It is conclusively shown, however, that the coldest place in the world is not, as might be supposed, among the mountains of the South Pole, but directly over the equator at a height of 18 km.

## Convection and Local Variations

Whenever a body of air becomes warmer than the surrounding air on the same level it must rise, and convection currents must be set up. It is well known that this process of convection plays no small part in the production of wind, cloud and rain, and some consideration of it is essential to any understanding of the atmosphere. As the body of air rises it expands with the decrease of pressure, and, since there is no source from which it can secure additional heat energy, the expansion must be adiabatic and the rising air must be cooled. A calculation based on the ordinary gas laws shows that in such a case the cooling proceeds at the rate of 9.7 $T'/T$ °C. per km. change of height for dry air (slightly less for moist air), where $T'$ is the temperature of the rising mass and $T$ that of its surroundings.[6] It can also be shown that in a dry atmosphere where the temperature fell uniformly at the rate of 9.7° C. per km. it would be possible to move a mass of air freely from one level to another without any expenditure of energy. Such a condition is known as "convective equilibrium", and is characteristic of the troposphere.

It was stated above that the average temperature gradient in the troposphere is about 7° C. per km. However, examination of single records of sounding-balloon flights shows that in general the gradient approaches the value of 9.7° per km. characteristic of "convective equilibrium" throughout layers of considerable depth, and that these layers are then more or less sharply divided by "inversions", or comparatively shallow layers where the temperature is nearly uniform, or may even increase with height (see Fig. 2*b*). These vary from day to day in height and extent, and the effect of taking the average of a large number of records is to smooth out these discontinuities, and to make the gradient appear uniform but somewhat smaller than the equilibrium value.

A rising warmed mass of air can continue to rise only so long as it remains warmer than its surroundings, and it is obvious that a limit to the process of convection must be reached even in an atmosphere where the temperature gradient has the equilibrium value throughout, since the cooling of the rising mass proceeds somewhat more rapidly than the natural temperature decrease

with height in the surroundings. Generally, however, the convection will be stopped when the rising mass reaches an "inversion", and only very vigorous convection currents will be able to rise through such a layer. In no case can it proceed to any extent into the great inversion which forms the stratosphere.

The natural "ceiling" formed by an inversion in the lower levels can frequently be observed on a calm day when the smoke rising from a city is carried by convection up to the level of the inversion, so that the haze is seen to have a definite upper boundary above which the atmosphere is clear. Such low-lying inversions often occur, for example, in the extreme cold-waves of the Canadian Northwest, when balloon flights have shown that the temperature at a height of a few kilometres is not abnormally low. It is now believed in fact that this phenomenon is a very characteristic one in temperate regions, and that the day to day variations in the atmospheric inversions are very intimately connected with the variability of the weather. Currents of warm air from the south and currents of colder denser air from the north are continually meeting along an indefinite shifting line which has come to be known as the "Polar Front". These currents do not mix directly, but the warm moist air tends to rise up over the colder current, causing an atmospheric inversion, and by its expansion as it rises, causing cloud and rain.

While the whole subject of these inversions and their exact relation to weather conditions is still somewhat imperfectly understood, it is clearly recognized that the shifting of the polar front from day to day is an extremely important factor in the development and movement of the cyclonic low pressure areas which are the immediate cause of weather variations in temperate latitudes. It is also clear that a careful study of individual balloon flights will eventually yield a great deal of information concerning the polar front, and that the data of these flights could be of the greatest value to the forecaster if he could get it each day in time to apply it in his calculations. But, what lies behind this again, and what causes the shifting of the front, is still lost in the mystery of the atmosphere. In spite of the vast volume of records and weather maps that have been compiled and studied, the meteorologist has to admit that he soon runs into the problem of which comes first,

the hen or the egg, whenever he leaves the field of normal conditions and general world circulation, and tries to trace to their origin the ordinary day to day fluctuations. With this reminder, then, that the atmosphere is a moving body, and that its structure is continually fluctuating round the mean, what follows will deal with normal conditions and average structure, where scientific theories can be more easily applied.

## Limitation of Convective Equilibrium

It is not difficult to show that there must be a lower limit to the temperature of the earth's atmosphere, and so to explain the existence of the stratospheric inversion which all over the earth limits the height to which convection processes can extend. The temperature of the earth as a whole is determined by equilibrium between the energy it receives from the sun in the form of light, and the energy it re-emits in the form of long heat-waves. The energy emitted by the earth is equal to $\sigma T^4$ ergs per sq. cm. per second by Stefan's Law of Radiation, where $T$ is the effective absolute temperature of the earth as a whole, and $\sigma$ is a well-known physical constant. Thus if $A\sigma T^4$, where $A$ is the area of the earth's surface, is equated to the known amount of energy received from the sun (corrected for a certain amount of sunlight reflected or diffused by the upper atmosphere and clouds), it is found that the effective temperature $T$ of the earth ought to be 252° A., or −21° C[7]. This is very much less than the temperature of the surface, but the atmosphere itself acts as a blanket and prevents part of the long heat-radiation from escaping, so that the temperature at the surface is able to rise to 14° C.

The atmosphere around 20 km. is practically free from water vapour, and so is almost completely transparent to the radiation from the sun, whatever it might absorb having been already removed from the incident radiation in the layers above. It is therefore heated almost entirely by radiation from the earth, and its temperature is determined by equilibrium between the energy it receives from below and the energy it re-emits in both directions. This temperature can be calculated by applying the same physical principles as in the calculation of the temperature of the earth.

Taking −21° C. as the effective temperature of the layer which is responsible for the outflowing radiation, Humphreys thus finds −61° C. for the lower limit to the temperature of the atmosphere at heights removed from the direct influence of the surface. The close agreement between this calculation and the observed average temperature of the stratosphere will be noticed.

Again, similar considerations are capable of explaining, qualitatively at least, why the temperature of the stratosphere is lowest over the equator. It is not the temperature of the ground or the energy received from the sun which enters into the calculation, but rather the temperature of that surface which is sending out the radiation to the upper layers, and whenever high clouds are present this may be taken to be their upper surface. At the equator the average amount of cloud is very much greater, and the clouds are usually higher, than at the poles. The effective surface temperature as seen from without is therefore lowest at the equator, and the temperature in the upper air can, and does, fall very much lower there.

It is found then that the surface of the earth is maintained at 14° C. by the blanketing effect of the atmosphere, mainly due to the water vapour and cloud in the lowest layers. The lower atmosphere is then heated from the earth partly by radiation and partly by convection. At first convection is the more important, and the temperature in the atmosphere is controlled by this process so that it falls off according to the law of convective equilibrium just to that point where it is fixed by the radiation from below. Then convection is automatically stopped by the inversion of the temperature gradient, and radiation becomes the important factor. Going to higher levels still, the ozone layer is reached, where a part of the incoming radiation from the sun is absorbed, so that above 50 km. the atmosphere probably receives a considerable part of its heat directly from the sun, and so may very easily be warm again.

## Wind in the Free Atmosphere

Increasing interest has been taken in recent years in the distribution of wind currents in the free atmosphere, fostered to a great

extent by the increasing interest in aerial navigation. Unlike the temperature observations in the upper air, wind currents, up to the cloud level at least, can be measured by an observer on the ground. Hence the information obtained can be made immediately available to aeroplane pilots, and can be utilized in the preparation of the daily forecasts. These immediate uses have encouraged the establishment in nearly every country of a considerable number of meteorological stations at which the recording of the upper winds is part of the daily routine of observation. In Canada these wind observations were for several years made at a few places mainly for experimental purposes, but with the great development in commercial aviation which has taken place within recent years, a number of stations have now been established which make daily reports by telegraph of the upper winds.

The observations are made by means of small gas-filled balloons without any instruments attached. The balloon is simply released and then watched from the ground through a theodolite, by means of which its azimuth and angular elevation are recorded each minute. When observations have to be made after dark, a candle in a small paper lantern is attached to the balloon. In order to find exactly the height of the balloon at any instant simultaneous observations of its elevation with two theodolites would be required, but it has been found that the rate of ascent is very nearly uniform unless there are strong vertical air currents, and that it can be calculated from the weight and lifting power of the balloon. Thus in the ordinary daily routine only one theodolite is used, and the balloon is assumed to be rising uniformly at the calculated rate, so that its height at any time is known. The horizontal distance of the balloon from the point of observation can then be found from the angular elevation, and a plan can be drawn of the horizontal path it has followed while rising. From this the direction and velocity of the wind at any level can be readily determined.

Two experienced observers, one watching the balloon, and the other recording its positions and plotting its path, can complete the calculations of the winds within a very few minutes of the time the balloon is lost. The results of this, together with data of cloud and visibility conditions, are then put into code and tele-

graphed to the forecasting office in the same way as the ordinary meteorological observations of temperature and pressure. At the main office maps are then drawn showing the wind currents over the country at various levels.

Unfortunately this method of observation of the upper winds depends for its success upon the weather conditions themselves. In the majority of observations the balloon passes into a cloud, or disappears in the distance owing to poor visibility, and is lost to view in a few minutes, so that records above about 5 km. are rather rare. High flights can only be obtained in fine weather, and the highest only when the wind velocities are not too great, or when as sometimes happens, a change of the wind direction in an upper level brings the balloon back overhead. However valuable the observations may be for day-to-day forecasting and for furnishing information of present conditions along aeroplane routes, the fact that only certain types of weather are selected makes them practically useless for compilation of normal conditions above 1 or 2 km. altitude. The present knowledge of the wind currents in the upper levels is in fact rather limited, and what is known is largely theoretical.

There is a definite mathematical relation between the wind velocity and the horizontal pressure distribution, which has been found to agree very well with observation as soon as a sufficient altitude has been reached to escape the influence of the surface topography. The wind in the free atmosphere blows along the isobars (or lines of equal pressure on the weather map) with the high pressure on its right in the northern hemisphere, the velocity depending upon the distance between successive isobars and increasing when they are closer together. If then the pressure distribution is known at any particular level on any particular day, the direction and velocity of the wind can be determined with fair accuracy. By making use of this relation, the normal winds in the upper air over the British Isles have been calculated from the results of observations of pressure with sounding balloons.[8] Another valuable series of high-level observations which is more or less independent of weather conditions has been made at Lindenberg, Germany, by means of kites.

Some facts of interest do appear, however, from the little that

is definitely known. In the temperate zone the marked characteristic of the wind and weather at the surface is its variability, owing to the successive passage of areas of high and low pressure. It is found that while the wind velocity increases very noticeably with increasing height throughout the troposphere, the variations to a considerable extent disappear. The easterly winds which are characteristic of an approaching area of low pressure, and which are so frequently an indication of wet weather, are often quite shallow, turning around to the west long before the stratosphere is reached, so that the influence of the local variations is slight in the upper levels. Even the persistent northeast and southeast trade winds of the sub-tropics appear to be reversed at a few kilometres elevation. The greatest winds are found near the base of the stratosphere, and appear to be mainly dependent upon the general world circulation of the atmosphere, due to the difference of temperature between the equator and the poles. They are consistently westerly in the temperate zone, with an average velocity over Europe of about 40 miles per hour, and easterly in equatorial regions with a velocity of perhaps 25 miles per hour. Within the stratosphere the westerly winds of middle latitudes begin to fall off in velocity until their direction eventually becomes reversed and at very great heights a general easterly wind is found. This has been observed on several occasions when great volcanic eruptions have thrown dust to great heights, which has then been carried around the world from east to west with a speed of about 50 miles per hour. This general east to west drift amounts in fact to a lag in the rotation of the extreme outer layers behind that of the solid earth of about one hour per day at the equator.

## Water Vapour and Cloud

From the meteorologist's point of view the most important part of the composition of the atmosphere is the water vapour. It is the factor which determines the weather conditions, fine, cloud, or rain, and at the same time it is the one variable factor, changing from day to day and from place to place over the earth, so that it may form anything up to about 4% by volume of the gas mixture. The very processes of atmospheric circulation are to a great extent

dependent upon the proportion of water vapour present, since moist air is lighter than dry air and tends to rise. No discussion of the lower atmosphere can therefore be complete without some consideration of its water content. Here a certain distinction has to be made between water in the form of vapour and condensed water drops or cloud, rain being considered as an extreme form of cloud, occurring when the drops become too large to remain suspended in the air. Vapour is always present to a greater or less extent in the lower levels, even in the most arid climates where cloudless days are common, and is an essential part of the composition of the atmosphere, while the clouds are merely held in suspension and are carried about by the circulation without having much direct effect upon it except to ensure that the air in their vicinity is kept saturated with vapour.

Fig. 5 shows graphically the average water vapour content of the lower levels plotted against the height, based on records of humidity obtained in a large number of sounding balloon flights at various European stations.[9] The solid lines represent the actual amounts of vapour at the various levels in grams per cubic metre, for both summer and winter flights, and the broken lines show the per cent. proportion by volume which this vapour bears

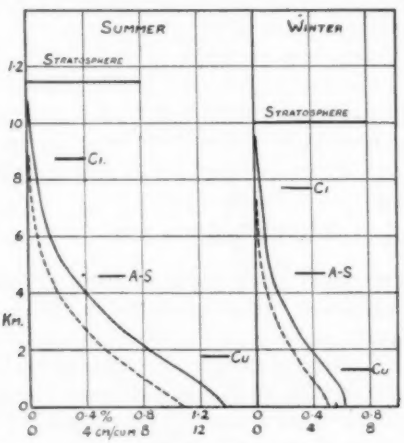



FIG. 5.—VERTICAL DISTRIBUTION OF WATER VAPOUR

to the atmosphere as a whole. It is seen at once that the all-important moisture is practically confined to the lowest levels, and that this must be the case is easily understood. The amount of water vapour which is required to saturate the air decreases very rapidly with decreasing temperature, and a rising moisture-laden body of air very soon reaches a level where the vapour present exceeds the saturation amount, and then the surplus must condense and form cloud. Therefore most of the vapour in the atmosphere, which is supplied from the surface by the evaporation of seas and lakes, only rises to a comparatively low level before it condenses into cloud and eventually returns to the ground again as rain or snow.

Observations of clouds, their forms and motions, have long been a matter of regular routine at all meteorological stations, since this is the one upper air observation which can be made without expensive apparatus. Measurements of their height, without which the observations are less valuable, have not been so regular, but this is also fairly easily observed, and a great deal of information has been obtained. At the present time heights of clouds are generally measured by means of the small pilot balloons which are used for determining the air currents. When these happen to pass into a cloud, as very frequently occurs, the height of the cloud base and its exact motion are given at once. For cumulus clouds, and other types with more or less marked structural features, direct measurement of the height by triangulation is also possible, and many observations have been made in this way.

Different levels in the atmosphere have their characteristic forms of cloud, so that average heights can be given for each of the recognized cloud-types. Three of these average heights are shown in Fig. 5. "Ci" indicates the very high tenuous Cirrus and Cirro-Stratus clouds, composed of ice crystals in the cold upper levels, and seen generally as feathery wisps against a blue sky. "A-S" indicates the gray sheet of Alto-Stratus through which the sun often shines dimly, and also the grayish rounded or corrugated masses, usually arranged in a more or less definite pattern, of Alto-Cumulus. Both of these generally occur at an intermediate

level, although the latter merges gradually both in appearance and in height into the small white masses of Cirro-Cumulus or Mackerel Sky, which may be nearly as high as Cirrus. These intermediate clouds may more or less cover the sky, but seldom give rise to rain, although a light sprinkle or snow-flurry may fall from Alto-Stratus. "Cu" indicates the familiar heavy masses of Cumulus, ordinary Nimbus or rain-clouds, and the heavy gray rolls of Strato-Cumulus, all of which occur at comparatively low levels, and which alone contain sufficient water to give rise to heavy rain.

For the formation of cloud two things are essential, the presence of water vapour in sufficient amount to cause saturation of the air, and cooling of the saturated air in order to produce actual condensation. The cooling can be produced by mixing of warm and cold air, or by a current of warm air passing over a cold surface, a common cause of fog. But much more frequently it is due to the uplifting of moist air and consequent adiabatic expansion according to the law of convective equilibrium. A certain amount of dust in the atmosphere also aids materially in the formation of clouds by providing nuclei around which the water droplets can condense. Without such nuclei it is indeed doubtful if clouds could form to any extent, since then the amount of water vapour present would have to exceed the saturation amount by several times before actual condensation would commence.

It has already been observed that vigorous convection processes are limited to the troposphere, and also that the layers above are practically free from the ordinary atmospheric dust. It is now seen that the stratosphere is also very dry, and we can safely conclude that clouds are almost if not quite impossible in that region. This is actually found to be the case, as is shown in the figure, where even the very light cirrus clouds are found to be well below the base of the stratosphere. The heavy rain-bringing clouds are in fact formed only at very much lower levels, as only here is the temperature sufficiently high for the necessary volume of water vapour to exist. Once formed, however, the cloud-droplets may be carried to considerably greater heights by vertical air currents, as is observed in the towering cumulus and thunderstorm clouds, whose tops frequently extend to 5 km. or more.

## Conclusion

Some attempt has been made to describe and explain briefly the principal features of the structure of the atmosphere, and it has been found that in any such discussion it must be divided into three more or less distinct layers, whose separation is first of all made evident by the differences in the temperature distribution, but which have many other strikingly different properties and phenomena.

First is the troposphere, warmed mainly from below through absorption of solar radiation by the earth's surface and by the clouds; the region of convection, characterized by a decrease of temperature with height. This layer contains 80% of the mass of the atmosphere as a whole, and almost all of the water, both vapour and cloud. In fact, only here is it possible for clouds and rain to be formed, and this might therefore be called the region of weather phenomena. Whatever may eventually turn out to be their ultimate cause, it is within this region that all those vagaries of fine weather and storm take place which make the weather the interesting subject that it is, and the practical meteorologist seldom has to look higher than the few kilometres of the troposphere.

Next comes the stratosphere, the cold dry layer of nearly uniform temperature, always above the clouds, and practically even devoid of water vapour. Convection currents from below hardly reach it, and at the same time it is too deep in the atmosphere to come very much under the direct influence of the sun, whose rays have already undergone as much absorption as is possible in dry air before penetrating so far. A negative region, whose only active phenomenon is the steady wind circulation of gale force.

Above the stratosphere the atmosphere becomes more active again in the diffuse outer levels of the ozone layer and the aurora borealis. Only one thousandth of the mass remains, but it is this fraction which is mainly responsible for the absorption of the ultra-violet rays from the sun, and so it becomes warmed and set into the electrical activity which we observe in the aurora and other phenomena of the upper atmosphere. Through these phenomena the outer levels are brought to our notice, and in some respects the last thousandth is as interesting as the first 80%. It is not un-

likely in fact that the outer layers will be shown to have a certain indirect influence upon the weather of the inner, through variations in the amount of absorption which takes place.

What has been described is mainly observed fact, with a few simple theoretical deductions and explanations, and beyond that point it is still unsafe to venture in the discussion. Much as meteorologists have discovered about the atmosphere, far more still remains to be found, and the great problem of explaining the weather variations has barely been touched. Progress is necessarily slow, both on account of the great complexity of the subject, and also because the meteorologist cannot perform his experiments in the laboratory, but must wait until the phenomena which he wishes to study happen to occur.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# THE POLE STAR*

By A. Vibert Douglas

THE Pole Star is of special interest for two reasons, first because it is a giant star many times larger, heavier and brighter than our sun and a star with interesting and perplexing physical peculiarities, and secondly, because it is the star that gives us our easiest first approximation to the true north direction.

Dwellers in the northern hemisphere of the little planet, earth, at the present time are very fortunate in having a fairly bright star very close to, though not exactly at, the point in the heavens towards which the axis of the earth is pointing. Dwellers in the southern hemisphere are not so fortunate, for the south pole of the earth's axis is directed towards a region of the sky quite devoid of any bright naked eye stars. True their much famed Southern Cross points towards the south pole of the sky but this group of stars being about 30° from the pole is not in itself sufficient to locate the south polar point.

But in the northern sky there is this fairly bright, second magnitude star within a degree and a quarter of the true north polar point. This star is Alpha Ursae Minoris, that is, it is the brightest star (hence the Greek letter *alpha*) of that group or constellation of stars called Ursa Minor or the Little Bear. Probably it was the Chaldean astronomers of ancient Babylonia, several thousand years B.C., whose vivid imaginations led them to name the various groups of stars, which they had very carefully charted, after various animals, birds, fish, dragons, and mythological objects and characters.

As the earth rotates once on its axis every twenty-four hours, anyone looking out at the stars is being swept around beneath them from west to east, but since the earth seems so firm beneath our feet we are unaware of its rotation by any sensation of motion and so it is natural to think of the stars as moving overhead from east

*Address broadcast over CKAC, Montreal, by request of the National Council of Education, 1931, March 13.

to west. Those stars near the Pole appear to describe circles around it. Actually the Pole star likewise describes a circle about the true polar point, but being so near this point its circle is too small to be observed casually. Hence the lines of Shakespeare referring to the Pole Star,

> Of whose true-fixed and resting quality
> There is no fellow in the firmament.

But many centuries before the time of Shakespeare astronomers knew that this was entirely an accidental attribute; this apparent fixity is due entirely to the fact that the earth's axis points towards this star at the present time. It has not always been so, nor will it long remain so. The rotating earth is wobbling like a spinning top and hence our axis does not point always in the same direction but traces out a wavy circle in the heavens. In the course of about 26,000 years the north polar point in the sky moves once around this circle passing successively through portions of the constellations Draco, Ursa Minor, Cepheus, Lyra, and Hercules. When this polar point passes near a bright star in one of these constellations that star for the time being is designated as the Pole Star by the inhabitants of the earth.

In the year 2170 B.C. the pole was very near to the bright star Alpha Draconis, and consequently this star was the Pole Star of the ancient Chaldean astronomers whose observations of the stars and planets led to much important scientific knowledge which was brought to Greece by Callisthenes. The comparison of this information about the stars as they appeared between 2000 B.C. and 3000 B.C. with the observations made by the Greeks about 250 B.C. led Hipparchus to the great discovery of the motion of the north polar point amongst the stars.

The explanation of this motion, known as *precession*, was given by Sir Isaac Newton nineteen centuries afterwards.

For another 500 years or more the present Pole Star will retain its usefulness for us as indicating the northerly direction, but after that the pole will move further and further from this star. People will cease to call it the Pole Star, and for centuries there will be no convenient bright star to assume the role. In about 12,000 years, however, the pole will have approached fairly close to a very bright

and beautiful bluish white star that we all know and admire, Vega, in the constellation Lyra. This will be the Pole Star to those who walk the earth 120 centuries hence. In imagination we watch yet another 12,000 years roll by, the pole will have almost completed a circle so that our own familiar Alpha Ursae Minoris will have been reinstated as the Pole Star.

By the methods of modern astronomical investigation, a great many interesting things have been discovered about this star.

It is much larger and brighter than our sun. It probably contains about 20 times as much matter as does our sun. This is determined by means of what is called the Mass-Luminosity Law propounded by Professor Sir A. S. Eddington of Cambridge, seven years ago. This relation tells us approximately how massive a star must be if we know how bright it really is. The brightness or absolute magnitude of our Pole Star is said to be $-3.7$ which means that it is giving off 4,800 times more light and heat per minute than the sun.

It is only its tremendous distance from our sun and solar system that makes this giant star appear as merely a shining point of light.

By the colour of the light that comes to us from this star, we can form an estimate of its surface temperature. This comes out to be about 7000° Centigrade, the surface temperature of the sun being somewhat less than 6000° Centigrade. The temperature at the centre of such a star must be many millions of degrees. Such temperatures are totally beyond anything imaginable by most people but they are not fanciful nor meaningless to the astronomer and the physicist. They think of temperature of a gas for example, as indicating the rate of motion of the atoms composing the gas. In air at ordinary room temperatures the atoms are zig-zagging about at an average speed of 1500 feet per second, but at the centre of one of these giant stars the atoms are rushing madly hither and thither at speeds of 100 miles a second, colliding with one another, bouncing off and radiating energy which spreads out like waves, and works its way outward through the star, finally escaping from its surface as light and heat.

The Pole Star belongs to a class of giant stars, all of them much larger than our sun, known as Cepheid Variables. Its light is

not quite steady, but increases slightly in brightness for about two days and then grows fainter again for two days. This variation goes on year in and year out with clockwork regularity. One explanation for these periodic changes is that such a star is actually pulsating, alternately swelling and contracting. The spectrum gives evidence of such a throbbing, showing that the surface of the star is sometimes rushing towards us and two days later is receding from us at the same velocity.

These changes in volume of the star result in alternate heating by compression and subsequent cooling of the surface layers of the star, and hence the light that is emitted by the star varies periodically not only in total intensity but also in quality as seen by the spectroscope..

More than 100 spectrograms of Polaris covering every phase of its variations have been taken at the Dominion Observatory, Ottawa, and in the course of a joint investigation of the spectra of some of these stars undertaken by the Dominion Observatory and McGill University, we have made highly magnified microphotometer tracings of the spectrum of the light from the Pole Star as recorded by the 15-inch telescope at Ottawa. The study of the starlight by this method has given us considerable valuable information about the physical changes that are going on —changes in temperature, changes in pressure, changes in the electrical state of the atoms of the gases forming the surface layers of this great star.

The Pole Star is, of course, composed of the same substances that our sun and earth are made of—hydrogen, oxygen, carbon, silicon, iron, titanium, magnesium, calcium, to name but a few of the elements familiar to chemists as the building bricks of all the known compounds, organic and inorganic.

In conclusion let us consider how far away the Pole Star is. To express this distance in miles would be more foolish than to measure the distance from Montreal to Vancouver in inches. Remember that the distance to the sun from the earth is 93,000,000 miles. Now consider that Polaris is 28,600,000 times as far from us as is the sun. Light travels 186,000 miles in a second. It comes from the sun, therefore, in just over 8 minutes, but to reach us from the Pole Star light travels for 466 years. The distance has

been measured at Greenwich, Royal Observatory, by direct trigonometrical survey of the sky, such measurements being amongst the highest achievements of astronomy during the last ninety years, for it is almost exactly ninety years since the first star distances were determined.

The Pole Star is thus so remote that the light we see when we look up at it tonight left that star about the time that Columbus was sailing the uncharted Atlantic, and the light from this star that guided that great navigator to the new continent had been journeying through space from Pole Star to earth since the days of William the Conqueror!

And yet, remote though this star be, its distance is insignificant when compared with some of the giant stars in the Milky Way and of the yet more distant spiral galaxies.

It is a great satisfaction to have been able to add something to our knowledge of the Pole Star, thanks to the co-operation of the Dominion Observatory, but how much greater would be our satisfaction if we had an observatory of our own and could take our own photographs with our own telescope and nightly interrogate the stars, reading in the starlight answers to some of the great riddles of the Universe!

## REVIEW OF PUBLICATIONS

*Standard Four-Figure Mathematical Tables,* by L. M. Milne-Thomson and L. J. Comrie. Pages XVI, 245, $7\frac{1}{2} \times 10\frac{1}{2}$ in. London: Macmillan, 1931. Price, 10s. 6d.

There has just come to hand these very extensive four-figure mathematical tables. They are published in two editions, A and B. In edition B the logarithms are given with negative characteristics, and in edition A, ten has been added to make the characteristics positive.

The following is a table of contents: Logarithms of the natural numbers from 1 to 2,000, 4 pp. Antilogarithms, 4 pp. Addition and subtraction logarithms, 4 pp. Roots, powers and reciprocals, 24 pp. Natural and logarithmic trigonometrical functions in degrees and decimals, 13 pp. Natural and logarithmic trigonometrical functions in degrees and minutes, 45 pp. Natural and logarithmic trigonometrical functions in radians, 36 pp. Natural and logarithmic hyperbolic functions and powers of $e$, 31 pp. Multiples of the modulus $M = \log e$, 1 p. Inverse trigonometric and hyperbolic functions with the argument in radians and natural logarithms to the base $e$, 43 pp. The gudermannian in radians $\int_0^x \operatorname{sech} x\, dx$, 2 pp. The inverse gudermannian, 1 p. Multiples of $1/M = \log_e 10$ 1 p. The gamma function, 1 p. The probability integral called erf. $x$, 1 p. Coefficients for interpolation, 2 pp. A table for the conversion of radians to degrees and degrees to radians, 1 p. A short table of integrals, series formulae, differential equations, constants and proportional parts, 30 pp.

The tables are published on very durable paper in good clear type and with the supplement, which was reviewed in a former number of this JOURNAL, giving the natural and logarithmic trigonometrical functions with the argument in time, they constitute a very complete set of four-figure tables. They are the most complete set of four-figure tables that we have seen.

R. K. Y.

*Les Observatoires astronomiques et les Astronomes* par P. Stroobant, J. Delvosal, E. Delporte, F. Moreau et H. L. Vanderlinden, de l'Observatoire royal de Belgique. 315 pp., 6 × 9 in. 1931. Price, 10 Swiss francs.

In 1907 M. Stroobant and his colleagues published a useful volume bearing the same name, and this is a new edition bringing the information as nearly as possible up to date.

The first part contains a list of observatories arranged alphabetically, according to location. The information given includes geographical position, members of the staff, date of foundation, instrumental equipment and publications. Then follows a list of astronomical societies in order of seniority, and finally there is an index to the names of persons.

Copies may be obtained from H. L. Vanderlinden at the observatory, Uccle, Belgium. C.A.C.

*Das Vorkommen der chemischen Elemente im Kosmos,* von Harald von Klüber. Pages, VII—170, 6¼ × 9¼ in. Leipzig: J. A. Barth, 1931. Price, bound, 20 RM.

When one looks back on the short history of astrophysics one must wonder at the multitude of facts which have been discovered and the remarkable theories of the construction of the universe which have been based on them.

From the first demonstration by Kirchhoff in 1859 that sodium and iron existed in the sun the search for other elements has continued, and here is a volume entirely devoted to a discussion of the chemical elements which exist in that part of the universe beyond our earth. A sequel will deal with our planet.

In regular succession the book takes up meteorites, the moon, comets, the sun, the fixed stars and nebulae. There is an exhaustive analysis of the literature on each topic and at the end is a list of 292 contributions which have been consulted. The treatment is non-mathematical, and in each case there is a comprehensive summary of all the published information on the various subjects. The book contains a full index, and is well printed. The author, who is on the staff of the Astrophysical Observatory at Potsdam, has produced a valuble work of reference. C. A. C.

*The Realm of the Air*, by Charles Fitzhugh Talman. Pages, 318, 5¾ × 8½ in. Indianapolis: Bobb-Merrill, 1931. Price, $4.00.

The author of this book is in charge of the very extensive library of the U.S. Weather Bureau at Washington, and has utilized the facilities he thus possesses to become well informed in all topics relating to the weather. He is a prolific writer on meteorological subjects and some of the chapters presented here have already appeared as magazine articles.

The book is full of interesting matter and is illustrated by twenty-nine remarkable photographs. The author refers to showers of fish, blood, manna; red snow and mud rains; tornadoes and ball lightning; and many other extraordinary things. These various phenomena are simply described and lucidly explained. At any time one may spend a pleasant and profitable quarter hour by reading any chapter at which the book may happen to open.

C. A. C.

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STARS

Night, and the splendor of a thousand stars
That ride triumphant with the glorious moon—
Here wheels through space the blood-red flame of Mars,
There lovely Venus blazes forth her noon.
In rings of golden light the flaming wheels
Of lordly Saturn ride upon their way.
Swift Aries o'er the vault of heaven steals,
While kingly Arcturus holds his sway.

There queenly sapphires burn beyond the fold,
Serenely silent in the eternal sea
Of outer darkness, infinitely old
As Time and Fate and pangs of Destiny—
Still stoics of the cold primeval dawn
Ere yet this puny sun were come to light;
Monarchs of mighty universes gone
Into the shades of long-forgotten night.

See, deep within the hazy eastern gloom,
A great star smoulders in a purple sky—
A thing of dread, to hang low o'er the tomb
Of some slain God, shorn of his deity—
Old heathen Sirius, long in Babylon
Worshipped in pagan temples, still he reigns
While shattered worlds and kings and creeds are gone
And Time alone through all the vault remains.

As some celestial bird-of-paradise,
Trailing its crimson glory through the deep,
A world in flames across the heaven flies,
O'ershadowing in its meteoric sweep
The paling light of envious stars and suns,
Across whose realms its course terrific runs.

A silver cloud steals silently between
The shimmering mazes of the Milky-way,
Like to a silken scarf, whose meshes screen
A million tangled fire-flies at play.
In dreams we tread that shining azure fold
And on our eyes the changing star-dust falls,
'Till in our tranced vision we behold
The golden city and celestial walls.

Still we dream on, while Night and Stars and Fate
Bear us through Time to where the immortals are,
Into those eons where but Love doth wait,
The one enduring faultless avatar;
Through tidal cycles of perpetual peace,
Where never pain or fear the being mars,
But still the spirit holds without surcease
Communion with the wise, the listening Stars.

Victoria, British Columbia. ALEX. H. SUTHERLAND.

## NEWS AND COMMENTS

Dr. Solon Irving Bailey, professor emeritus of astronomy at Harvard University, from 1892 to 1919 in charge of the Arequipa branch of Harvard College Observatory, died on June 5, in his seventy-seventh year. (*Science*).

Mr. R. Glenn Madill of the Dominion Observatory, Ottawa, departed in June to make terrestrial magnetic observations at stations previously established along the Mackenzie River. If time permits he will establish new stations at Fort Liard and Herschel Island.

Dr. Philip Fox, director of the Adler Planetarium, Chicago, received an honorary doctorate from Kansas State Agricultural College on the occasion of its sixty-eighth annual commencement in May, 1928. (*Science*).

Dr. R. J. Trumpler of the Lick Observatory, University of California, will spend a year's leave of absence, from July 1, studying in Europe.

Dr. Charles Lane Poor will retire from the chair of celestial mechanics at Columbia University at the close of the academic year, and will reside at Dering Harbor, Greenport, Maine.

Dr. Harlow Shapley, director of Harvard College Observatory, has been elected an honorary foreign member of the Royal Swedish Physiographic Society of Lund, and a foreign correspondent of the Royal Lombard Institute of Science and Letters. (*Science*).

Professor Kurt Wegener, formerly head of the Spitzbergen Observatory, will succeed, as leader of the German Scientific Expedition, his brother, Alfred Wegener, who died in Greenland.

Professor Albert Einstein, preliminary to delivering the third and last of his series of Rhodes Memorial Lectures at the University of Oxford on May 23, received the degree of doctor of science from the university.

Professor Willem de Sitter of the University of Leyden, will visit Mount Wilson Observatory during the coming winter.

Dr. Alexander McAdie, since 1913 A. Lawrence Rotch professor of meteorology at Harvard University, and director of the Blue Hill Observatory, will become professor emeritus next February and will be on sabbatical leave during the first half of next academic year.

Professor Jan Schilt, of Yale University Observatory, has been appointed head of the department of astronomy at Columbia University, and will take up his duties there about October 1.

The discovery of the last "missing" element, No. 85, has been announced by Dr. Fred Allison, Edgar J. Murphy, Professor Edna R. Bishop and Anna L. Sommer, working at the Alabama Polytechnic Institute.

Observations of meteors will begin about October 1, at special observing stations to be established by the Harvard College Observatory near the site of the Lowell Observatory at Flagstaff, Arizona.

REDeL.

## NOTES FROM THE DOMINION ASTROPHYSICAL OBSERVATORY, VICTORIA, B.C.

February was a little above the average for observing, March and April away below. The twelve-year averages for the number of hours observing secured are, in round figures, 92, 105, and 100, whilst 103, 85, and 79 hours, respectively, were secured in these three months.

Approximately 1,413 persons visited the observatory during the three months, as against 1,995 for the corresponding three months of last year.

Dr. S. J. McLean, the President of the Winnipeg Centre of the R.A.S.C., who, with Mrs. McLean, was sojourning in our city for a few weeks, spent a day or so with us, and listened in to one seminar discussion, giving us also a little summary of the work of the Winnipeg Centre.

Dr. Harry Spedder, a National Research Fellow of the Physics Department of the University of California, paid us a hurried visit in April. His work on the spectra of solids would have been very

interesting to hear, had we been able to persuade him to stay to give it.

Dr. Harald Petersson, who has made a valuable contribution to our knowledge of the density distribution of the stars from work carried out at Upsala, Sweden, is visiting the American observatories. He spent a couple of weeks in Victoria with his bride, during which time he visited the observatory frequently and gave us a delightful talk on Sweden and her astronomical work, a fuller report of which will appear in the JOURNAL elsewhere. He plans to enter the teaching profession on his return to Sweden.

The Director left about the middle of May to attend the meetings of the Royal Society in Toronto, there to present four papers by himself and other members of the observatory staff. On the way he addressed the Winnipeg Centre of the R.A.S.C. Possibly he may return by way of Pasadena, taking in the meeting of the American Association for the Advancement of Science, June 15th to 20th. W.E.H.

FOR SALE

ASTRONOMICAL TELESCOPE, equatorially mounted refractor with driving clock—objective by Wray, 4-in clear aperture, very complete with many accessories. Magnifying powers 25-400 and terrestrial eye-piece giving four magnifying powers. Observatory house of wood with sliding roof and shutters, may be easily transported.

This fine instrument is the property of Mr. A. S. Miller of Toronto. It may be seen by appointment. Full descriptive circular and particulars.

CHARLES POTTER, *Optician.*
16 Adelaide St. W., Toronto.

## NOTES AND QUERIES

**Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.**

### The Canadian Census

The decennial census of Canada is now being taken and it is hardly necessary for this Journal to urge all to co-operate with the authorities. A special effort is being made to obtain accurate and full information regarding merchandising and service establishments, as it is only on a knowledge of present conditions that we can build effectively for the future.

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### Venus as a Crescent to the Unaided Eye

Information regarding this matter has been published in our Journal during recent years, the last reference to the subject being in the March number of the present volume, page 131.

Dr. Roscoe F. Sanford, of the Mount Wilson Observatory, sends a very pertinent quotation from Vol. I of the report of the U.S. Astronomical Expedition to Chile (1849-1852), by Lieut. J. M. Gilliss, page 38, top. In speaking of the good seeing conditions experienced at Santiago, Chile, Gilliss makes the following statement: "The observer will appreciate me when he is told that I have made very fair micrometrical measurements of Venus when the planet was not more than 3° above the eastern horizon, and its crescent was more than once seen with the naked eye."

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### The Czech Astronomical Society

The annual report of this Society, dated March 12, 1931, shows that it is in a flourishing condition. It has 853 members and, in addition to holding meetings, publishes a journal. Its headquarters are at Stefanik's popular observatory, Prague, which has an extensive equipment, including an 8-inch comet seeker and a twin refractor of 8 and 7 inches aperture, both instruments by Zeiss. The president of the Society is Professor Fr. Nusl, director of the National Observatory at Prague, and the secretary is Mr. Josef Klepesta.

Recently the Society published a chart (by K. Novak), of the northern hemisphere of the sky, with the new limits of the constellations, and also a movable planisphere of the same, with a reduced copy of K. Andel's chart of the moon on the reverse side. The recent opposition of Eros was observed photographically by Mr. Nechville. During 1930 the members made 1,220 observations of the sun and 138 observations of bright meteors.

The present writer congratulates the Society on its excellent work.

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### Telescopes in Japan

Mr. Yasuaki Iba, a well-known amateur astronomer at Ohte, Suma, Kobe, has revised his list of astronomical telescopes in Japan, and it presents a very creditable showing. He gives 58 refractors of aperture 4 inches and upwards. Of these there are at the Tokio Astronomical Observatory a 26-in., a 15-in., three 8-inch, one 6-inch, and two 4-inch instruments; at Kisto there are a 12-inch and a 7-inch; and at Kobe Marine Meteorological Observatory there are a 10-in. and a 5-in. There are 51 reflectors, the largest being a 20-in. at Tokio (Nihon Kogaku Kaisha), and an 18-in. at Kioto (owned by Dr. I. Yamamato). There are 27 astronomical cameras in the list, of which eight are at the Tokio Observatory, six at Kioto (Kwazan Observatory), and four are in Mr. Iba's own private observatory.

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### Joint Meeting of R.S.C. and R.A.S.C.

At the recent annual meeting of the Royal Society of Canada, held in Toronto, the Royal Astronomical Society of Canada cooperated in a joint session with Section III. There were ten papers presented, as follows:

1. A. H. Miller, Surveys with the torsion balance and the magnetometer in Eastern Canada.
2. J. S. Plaskett and J. A. Pearce, The motions of the diffuse gaseous matter in the Galaxy.
3. C. A. Chant, The David Dunlap Observatory project.
4. C. C. Smith, Seasonal variations in adopted clock corrections.
5. J. A. Pearce, A remarkable stellar system.

6. W. E. HARPER, Comparison of Victoria radial velocities of A-type stars with those of other observatories.

7. RALPH E. DELURY AND JOHN L. O'CONNOR, Astronomical periods in climate and in living things.

8. C. S. BEALS, On the contours of emission bands in novae and Wolf-Rayet stars.

9. J. S. PLASKETT AND J. A. PEARCE, Investigations of the motions of the O and B type stars at Victoria.

10. A. VIBERT DOUGLAS, Cyanogen in stellar atmospheres.

The following papers were received too late to be considered for inclusion in the formal programme:

W. F. Whittier, Glacial Epochs, Why and When.
Dr. E. A. Smith, Radiation in the Dynamic Universe.
Gilbert, Lord Wilson, The Solar and Lunar Cycle.

In Section III, and later in the general session of the Society, the following resolution regarding the David Dunlap Observatory was passed unanimously:

Moved by J. S. Plaskett, seconded by Louis V. King, that

"The members of the Royal Astronomical Society of Canada desire to express their appreciation of the notable contribution to science which is being made by Mrs. D. A. Dunlap in undertaking the erection of a well-equipped astronomical observatory, which will give additional facilities for research to the University of Toronto.

They recognize that this great observatory will be an appropriate and enduring memorial to the donor's late husband; they also believe that in the years to come it will lead to a large increase in our knowledge of the universe and will bring distinction to our country."

The holding of a special scientific meeting of the Royal Astronomical Society of Canada in conjunction with the Royal Society of Canada was felt to have been to the advantage of both organizations. The arrangements were begun rather late for the recent session and from the experience gained it is believed there will be still closer co-operation in the future. The next meeting of the Royal Society will likely take place in Vancouver, B.C., in association with the Pan-Pacific Congress, which will be held there in June, 1932.

### Death of A. A. Michelson and W. F. Denning

Professor Albert Abraham Michelson, famed especially for his measurement of the velocity of light, for the Michelson-Morley experiment on the relative velocity of the earth and the ether, for his research on the rigidity of the earth, and for his measurement of stellar diameters, died on May 9, 1931, in his seventy-ninth year. A discriminating and appreciative sketch of him by Prof. Forest R. Moulton, appears in the June-July issue of *Popular Astronomy*.

William Frederick Denning, the well-known authority on meteors, died at Bristol on June 9, aged 82. He was an honorary fellow of the Royal Astronomical Society of Canada for over thirty years.

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### Parsons Association

The present writer learns that it is proposed to form an association to commemorate the life and work of the late Sir Charles Parsons, O.M., K.C.B., F.R.S. Membership is to be open to old employees of C. A. Parsons and Co., Limited, the Parsons Marine Steam Turbine Co., Limited, as well as to present members of these firms, both at home and abroad. Further particulars may be obtained from F. Jno. Bell, Royal Bank Building, Toronto.

C.A.C.

# MEETINGS OF THE SOCIETY

## At Montreal

*November 6, 1930.*—The first meeting of the session was held on this date at 8.30 p.m. in the Macdonald Physics Laboratory. The newly elected president, Dr. L. V. King, took the chair.

New members were elected as follows:

Dr. Lucien P. Peeves
Miss E. E. Everett
Miss N. Gatley
Mr. D. C. West
Mr. K. T. Cregeen

The speaker was Mr. R. Meldrum Stewart, Director of the Dominion Observatory, Ottawa. His subject was "Geophysics at the Dominion Observatory". Three aspects were dealt with—Terrestrial Magnetism, Seismology, and Gravity. In connection with each, the instruments were referred to and the general facts stated, and reference was made especially to the work done in various parts of Canada in making measurements and records. Of particular interest were the remarks regarding the Wegener Theory of Drifting of the Continents and its possible application to the phenomenon of the wandering of the magnetic poles; and the discussion of the Pratt and Airy Isostacy theories.

At the conclusion of the lecture, several questions were answered and finally a vote of thanks was tendered to the lecturer by Dr. MacCordick on behalf of the very appreciative audience.

*December 4, 1930.*—The second meeting was held at usual place and hour, the President, Dr. L. V. King, in the chair.

New members were elected as follows:

Mr. J. Heard
Mr. J. Katzman

The lecturer was Professor T. H. Matthews (late Lieut. R.N.) of McGill University, the subject, "Navigation and Astronomy".

The problem of finding a ship's position at sea was discussed clearly and in some detail.

The sun's geographical position was defined as the point on the earth's surface from which at a given instant the sun would be seen at the zenith. At the time of commencement of the lecture this point was at New Caledonia off the east coast of Australia. By the conclusion of the lecture, an hour later, the point would have travelled to a town called St. Lawrence on the east coast of Queensland.

The need and use of sextant, chart, spherical trigonometry, mathematical tables, compass and chronometer were explained, also the terms Dead

Reckoning and Fix. The log was discussed—its origin being that a log or piece of drift wood was thrown over at prow and timed as it was passed at stern. Later it was tied by a string having *knots* at intervals and these were counted as it was paid out for a certain time. Stock sentences were early used for timing—still done thus for timing shots in a salute. Columbus is said to have estimated speed by looking at the water! Astrolabes, quadrants and sextants were described and slides shown. The development of the accurate chronometer was traced from "Nuremberg egg" to modern instruments.

Charles II authorized the use of money from the sale of old gunpowder to get Wren to build Greenwich Observatory, primarily for purpose of finding the best means of determining longitude. Two methods and rivalry—Lunar Tables and Chronometers. A commission offered 20,000 pounds sterling for a clock which could go to W. Indies and back and keep accurate time. Harrison (Yorkshire farmer's son) put in regulator to counteract temperature change and his "chronometer IV" won the award. Position from it was only 1.25 miles in error on a test trip to W. Indies. The cost of the chronometer was 495 pounds. A later French improvement was a brass-and-steel balance wheel. This was about 1740. Lunar tables were completed by 1800. Greenwich chronometer testing rooms were shown in slides. On shipboard Sgt. of Marines summons Navigating Officer at 9 a.m. to wind chronometers. In 6 weeks error should not be 3 seconds. Thus the history of watches is linked up historically with needs and perils of men who go down to the sea in ships.

The President referred to the work of Euler and E. W. Brown on Lunar Tables, the changing speed of rotation of earth and consequent need for an independent time keeper, and hence the continued efforts as seen in the Shortt clocks.

In answer to questions the lecturer said Kew was the official time piece centre for civil and Greenwich for naval control and standardization. Also that sextant observations brought *lower limit* of sun to horizon.

*January 29, 1931.*—The *third* meeting for 1930-31 was held in the usual place.

Dr. L. V. King, President, occupied the chair, and introduced the lecturer, Dr. N. B. MacLean, who spoke on the "Solar System and its Origin", showing a fine collection of slides.

He outlined the Laplacian Nebular Hypothesis, the Chamberlin and Moulton and the Jeans and Jeffreys theories and gave a running account of many of the facts regarding size, relative position and physical features of the sun, planets, satellites, referring in particular to the discovery of Pluto. Some general remarks on nebulae, both diffuse and planetary as well as the spirals, followed.

A vote of thanks was tendered by Judge E. E. Howard, who referred to the 1932 eclipse.

The Secretary showed slides of the positions of the planets for January

and of the orbit of Eros whose closest approach to the earth was imminent. The astronomical significance of this was stressed.

*March 12, 1931.*—The *fourth* meeting at the usual hour and place. Dr. L. V. King, President, was in the chair.

After referring to the election of the Secretary to fellowship in the Royal Astronomical Society, London, the President called upon the lecturer, Professor A. H. S. Gillson, to address the meeting upon "The Nebulae".

The lecturer began with Roger Bacon's references to a telescope, referred briefly to Copernicus and Galileo and then mentioned Huygens' (1656) observations on the great Orion nebula; Messier, the comet hunter, and his catalogue; Mackay, the theologian and astronomer, who, influenced by Cassini, went to the Cape and catalogued 10,000 stars and some nebulae.

Wm. Herschel, musician who "to unbend his mind" read calculus and ground mirrors, constructed 7 ft., 10 ft., and 20 ft. (in length) telescopes, and made four sweeps of the heavens, finding Uranus on the second sweep, and compiling altogether three catalogues of nebulae, containing 1000, 1000, and 500 nebulae respectively. John Herschel continued and revised these and by 1894, 10,000 nebulae were known of which half had been listed by the Herschels. Wm. Herschel first used the term Island Universe.

Lord Rosse with his great telescope 60 ft. in length, noted the spiral arms of some nebulae. Sir Wm. Huggins first showed spectroscopically that whereas some nebulae are star clusters, others are diffuse glowing gas (1864). The evidence from star counts for the finitude and distribution of the stars was given—the galaxy $3 \times 10^{10}$ stars in a lens-shaped volume $3 \times 10^{3}$ light years by $5 \times 10^{4}$ light years. The Cepheid Law and Shapley's work upon clusters was outlined. Hubble's investigations since 1926 upon the spirals, especially his system of classification, were described. The problem of the recession of the spirals was discussed—galactic notation and the light thrown by this on the approaching velocity of M31. The hypothesis of Einstein, de Sitter and Lemaitre were briefly referred to in closing.

The thanks of the society were expressed by Dr. A. S. Eve.

Professor R. H. Fowler, Cambridge, who was present at the meeting, made some remarks upon the law of attraction acting within the galaxy which is involved in the analysis of the observable effects on the motions of the relatively near stars due to galactic rotation.

A. Vibert Douglas, *Secretary.*

At Winnipeg

*December 10, 1930.*—The regular meeting was held in Theatre A, University of Manitoba, at 8.15 p.m. The President, Dr. L. A. H. Warren, was in the chair.

At the conclusion of the business meeting, Dr. Neil John MacLean, Vice-President, took the chair, while Dr. Warren gave the address of the evening.

The title of the address was "Refraction of Light". Dr. Warren stated that the bending of rays of light was caused by their passing through media of different density; and gave a detailed explanation of the principles governing the laws of refraction. Referring to the positions of the sun and moon on the horizon, Dr. Warren said that their apparent elevation was caused by the refraction of the rays of light in their passage through the atmosphere, which made these heavenly bodies appear higher than they really are. Reference was also made to the flattening of the sun and moon when close to the horizon. Speaking of the spectrum, Dr. Warren discussed the formation of the continuous spectrum, the bright-lined spectrum and the absorption spectrum, and enumerated some of the elements recognized in the solar atmosphere as a result of spectroscopic observation.

After many expressions of appreciation to Dr. Warren for his interesting and instructive address, and after some discussion relating to the topic of the evening, the meeting adjourned.

*January 11, 1931.*—The regular monthly meeting was held at the same time and place. The President, Dr. Neil John MacLean, was in the chair.

The following were elected to membership in the Society:

Mrs. L. C. Johnstone, 890 McMillan Ave., Winnipeg
Mrs. W. J. McMartin, 278 Elm Street, Winnipeg
Mr. Percy N. Andrews, 401 Home Street, Winnipeg
Mr. Fraser Sweatman, 266 Kingsway, Winnipeg

The speaker of the evening was Professor V. W. Jackson of the Manitoba Agricultural College, and his subject was "Meteorites".

"Meteors suggest only the visible phenomena; meteorites, the material residuum which reaches the earth, are our only material evidence of the the universe beyond, and hence are of great scientific interest. Of the thousands of meteors seen, only about 1,000 reach the earth yearly and as three-fourths of these will be at sea, of the estimated 250 on land only an average of three are recovered. Of the 820 meteorites which have been found, 670 in whole or in part are in the Field Museum, Chicago. The meteorite of greatest interest is the bolide mass below the meteor crater in Arizona, an airplane view of which reveals a perfect crater, with a diameter of 4,200 feet and a depth of 570 feet, and a splash of detritus over the surrounding plateau for miles around, huge blocks of stone half a mile away, one of 7,000 tons was thrown out in an instant,—a total of 200,000,000 tons or one-fourth of the entire excavation of the Panama Canal. This interesting star dust, our only material evidence of the universe, is worthy of more attention than we have given it and it is hoped that any local phenomena will be reported, that we may know more about our universe and what is happening."

Professor Jackson also gave a report of the Meeting of the Astronomical Section of the American Association for the Advancement of Science which he recently attended in Cleveland, Ohio.

S. C. Norris, *Secretary.*

AT LONDON

*April 10, 1931.*—A regular meeting of the London Centre was held in the London Life Building. There were 60 people present. The usual observation period was conducted on the roof of the building; the four brightest moons of Jupiter were observed. At 8.45 a short business meeting was held, during which the following were elected to membership in the Society:

Mr. A. B. Crook, 390 Dundas Street, London
Dr. E. S. Detwiler, 446 Waterloo Street, London
Mr. R. Gordon, 559 St. James Street, London
Mrs. H. F Hunt, 614 Wellington Street, London
Mrs. F. Phelps, 838 Wellington Street, London
Miss S. Livingstone, Westminster Hospital, London

Mrs. S. J. Berry presented a review of "The Stars in their Courses", by J. H. Jeans. President McKone introduced the speaker for the evening, Major E. H. Anundson, who addressed the members on "Calendar Reform".

The speaker traced the history of the calendar from the year 7000 B.C., at which time there are evidences of some form of calendar being in use. There seems to have been a constant urge towards perfection, and the Great Pyramid of Gizeh, built between the years 4235 and 2450 B.C., was evidently used as a means of checking calculations on the sun by means of the shadow which it cast. There followed, the Olympiads of the Greeks, the lunar calendar of the Romans, which was followed by the Egyptian form introduced by Julius Caesar in 45 B.C., and known as the Julian Calendar. The superstitions which had a bearing on this calendar were discussed, such as the reason for starting the year on January first, and the reason for the varying number of days in the months. Then followed the changes made by Augustus Caesar, slight but important, and all of which are present in our calendar of to-day.

Calendar reform continued under Pope Gregory XIII, who, in 1577 A.D., appointed a commission to study a plan of reform which would overcome the very evident shortcomings of the calendar then in use, and which was getting further and further away from the seasons which it was supposed to mark. The result was the adoption of the Gregorian Calendar, which necessitated the dropping of ten days from the reckoning—October 5, 1582, becoming October 15. This Gregorian Calendar has gradually been adopted by the nations of the world, and with its adoption by Greece and the Greek Church as late as 1923, it is practically in universal use. The speaker pointed out that this calendar (excepting the fact that it starts on January 1), is to all intents and purposes astronomically perfect, the error being only one day in 200 centuries. It was pointed out that there was an error of four years in fixing the starting date of the calendar, and that the birth of Christ actually took place four years before the time set.

The various incidents leading up to the present plans for reform were discussed in detail, together with arguments both for and against the Thirteen Month Plan and the Swiss Plan. These arguments were covered from the viewpoint of religion, science, and business. It was shown that January 1, 1933, was a most logical date for the commencement of the proposed Thirteen Month Plan, but the speaker was of the opinion that it was extremely improbable that it would go into operation at that time, largely due to the lack of knowledge of the scheme by the general public. He felt that in order to successfully launch such a drastic change it would be necessary to give it all possible publicity and so create a more comprehensive knowledge of the uses and advantages of the scheme.

A very hearty vote of thanks to Major Anundson was proposed by Dr. H. R. Kingston and seconded by Rev. R. J. Bowen. Dr. H. S. Wismer pointed out that the name "Sol" for the extra month of the Thirteen Month Plan was not appropriate for the people of the Southern Hemisphere; the doctor suggested the name "Olympus" for this extra month. Mr. F. H. Coates demonstrated the photo-electric cell and discussed briefly its many uses in astronomy and other fields of science. The meeting then adjourned.

*May 8, 1931.*—A meeting of the London Centre was held at the same place and time. There were 61 people present, with one election to membership, *viz.*, Mrs. W. P. Burns, 422 Piccadilly St., London.

Mr. T. C. Benson conducted a general survey of the stars by means of a large scale chart. Miss A. E. Henderson gave an excellent review of Prof. C. A. Chant's "Our Wonderful Universe". The theory of refracting and reflecting telescopes was explained and demonstrated in a very able manner by Mr. F. H. Coates. The speaker for the evening was Captain L. F. Hansen, a retired British naval officer, who addressed the members on the subject of "Applications of Astronomy to Navigation".

The speaker gave a short sketch of the primitive methods of navigation which were employed by the Vikings. These early methods made use of the sun and the moon; Columbus determined longitude by means of occultations of the moon. In 1761 the first chronometer made its appearance; this instrument was as large as a packing case, and its error was only 5 seconds in two months. There are two ways of navigating. The first, known to the sailor as "Dead Reckoning", employs the Compass, the Log, and the Lead to determine position at sea. These instruments were described in turn, the captain emphasizing the fact that it was impossible to steer a straight course with a magnetic compass; the modern navigator has a new compass, the gyroscopic compass, which always points due north and not to the magnetic pole, as does the magnetic compass. The method of taking soundings by casting the lead has been replaced in modern times by discharging a shell from a gun into the water—the time between the discharge and the echo of the shell striking the bottom gives the depth. Dead reckon-

ing is not accurate—modern navigating requires an extensive knowledge of mathematical astronomy. The captain explained how such a knowledge is applied to determine latitude by means of the meridian altitude of the sun's centre. The longitude of a ship may be found by measuring the altitude of the sun, calculating the hour angle of the sun's centre, from which the local mean time is computed. The difference between this time and the Greenwich mean time, as shown by the ship's chronometer, is the longitude of the ship. The lecture concluded with a brief description of the method of obtaining both latitude and longitude by the simultaneous altitudes of two stars.

President McKone extended the thanks of the London Centre to Captain Hansen for his very interesting talk. The meeting then adjourned.

G. R. MAGEE, *Secretary-Treasurer.*

AT VICTORIA

*April 28, 1931.*—The subject for study and discussion at this meeting was Life in the Universe. The President, Dr. C. S. Beals, introduced the subject and spoke chiefly of the possibilities of life outside the Solar System. The following four members spoke of different aspects of the subject:

Dr. J. A. Pearce, Life on the Earth.

Captain J. H. Hughes, Conditions on Mercury, Venus and the Outer Planets.

H. Boyd Brydon, Lowell's Conception of Mars as the Abode of Life.

N. C. Stewart, New Information concerning Mars, gained at recent Favourable Oppositions.

Dr. Pearce dealt with the origin and evolution of Life. Captain Hughes gave a brief description of the probable origin of the Solar System, showing that the planets are composed of the same material, so that if conditions in other planets are similar in temperature and atmosphere there is probably life "as we know it". But there would probably not be life "as we know it" where conditions were different.

H. Boyd Brydon showed how the temperature on Mars was suitable for life. He described the "canals", some of which were 10 miles wide and 3,000 miles long. These seemed to be tracks of vegetation and conducted water from the poles towards the equator. N.C. Stewart, on the other hand, while admitting that the temperature on Mars was sometimes suitable for human life, said that at night it was freezing on the equator. He said that the atmosphere of Mars made it impossible to see sufficiently clearly enough to prove the existence of human life.

At the conclusion, Dr. Plaskett and Mr. Charles Hartley expressed the Society's thanks to the speakers of the evening. Several lantern slides, loaned by Dr. E. C. Slipher, Director of Lowell Observatory, were shown at this meeting.

P. H. HUGHES, *Secretary.*

AT TORONTO

*March 24, 1931*—A regular meeting was held in the Physics Building of the University at 8 p.m.; Mr. R. A. Gray in the chair.

There were five elections to membership:

Adolph Bernhardt, Canadian Junior College, College Heights, Alberta.
R. C. Sibley, Coalspur, Alberta.
Julien Peridier, 16 Rue Cassette, Paris, France.
W. S. Armstrong, Department of Astronomy, University of Toronto.
J. M. Spiers, 17 Wolfrey Ave., Toronto 6.

Mr. J. R. Collins referred to the receipt of a report from Harvard of a discovery of a new object in Leo. This has since been identified as a planetoid.

A description of Leo and neighbouring groups of stars was given by Mr. S. C. Brown.

The evening's lecture, "The Stars in Navigation," was given by Commander J. N. DeMarbois, formerly of the British Navy. Navigation, before the advent of instruments and calculated positions of heavenly bodies, was a matter of keeping in sight of land, though the Chinese were able to navigate far out to sea by utilizing the prevailing monsoon winds. The sextant and chronometer enable a navigator to find his position with a very close approximation. The Nautical Almanac gives the calculated positions of the heavenly bodies with the variations in right ascension and declination of the sun, moon and planets. The sextant measures the angular distance between any two points; therefore a latitude may be obtained by observing with this instrument the sun's maximum altitude, which occurs at the local apparent noon, and applying various corrections to give the true meridian altitude. The altitude is then calculated by the aid of a simple formula.

Longitude may be determined by measuring the altitude of the sun or a star near the prime vertical, from which is computed the hour angle and this is converted to the local civil time, the difference between this time and the ship's chronometer at time of observation gives the longitude. The chronometer indicates Greenwich civil time, and is constantly checked for accuracy at sea by radio.

Many questions were asked and a most interesting discussion followed the lecture. A vote of thanks to the speaker was passed unanimously.

# The Royal Astronomical Society of Canada

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## THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

The Astronomical and Physical Society of Toronto was incorporated in 1890, though it had existed some years before this; in 1900 it became The Toronto Astronomical Society; and on March 3, 1903, it was given permission to use the name, The Royal Astronomical Society of Canada.

Its objects are to study astronomy and cognate subjects, to publish the results of its work, and to maintain a library.

For many years the Toronto organization existed alone, but now the Society is national in extent, having active Centres in Montreal, P.Q.; Ottawa, Toronto, Hamilton and London, Ont.; Winnipeg, Man.; and Victoria, B.C. Among its 800 members are a number of leading astronomers and scientists of the world, many amateurs, and, in addition, many laymen who are interested in the culture of the science.

The Society publishes a monthly JOURNAL containing each year about 500 pages of interesting articles and a yearly OBSERVER'S HANDBOOK of about 80 pages, containing valuable information for the amateur observer. Single copies of the JOURNAL or HANDBOOK are 25 cents.

Membership in the Society is open to anyone interested in astronomy. Annual dues, $2.00; life membership, $25.00 (no further dues). Publications are free to the members, or may be subscribed for separately.

Extract from the By-Laws: Candidates who are elected to membership will be attached to a particular Centre, or to a section known as *Members at Large*. Members of the Society who live outside of Canada, or in a province in which there is no Centre of the Society will be considered *Members at Large* and not attached to any particular Centre, unless these members are expressly nominated for membership and attachment to a particular Centre. Members may be transferred from one Centre to another, or to the section *Members at Large* by the Council of the Society if written application for such transfer is made by such member to the Council.

The library and offices of the Society are at 198 College St., Toronto, Ont. Applications for membership or for further information should be addressed to a local secretary (see back of this page) or to the General Secretary at the above address.